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Original Article

Ethnic-specific associations of sleep duration and daytime napping with prevalent type 2 diabetes in postmenopausal women

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ABSTRACT

Objective: The objective of this study was to evaluate ethnic differences in the associations of nighttime sleep and daytime napping durations with prevalent type 2 diabetes.
Methods: Samples of White ($n = 908$), Filipina ($n = 330$), and Black ($n = 371$) community-dwelling, postmenopausal women aged 50–86 years were evaluated with cross-sectional data obtained during 1992–1999 including self-reported duration of nighttime sleep and daytime napping, behaviors, medical history, and medication use. The prevalence of type 2 diabetes was evaluated with a 2-h 75-g oral glucose tolerance test.
Results: Overall, 10.9% of White, 37.8% of Filipina, and 17.8% of Black women had type 2 diabetes. Average sleep durations were 7.3, 6.3, and 6.6 h and napping durations were 16.8, 31.7, and 25.9 min for White, Filipina, and Black women, respectively. Sleep duration showed a significant ($p < 0.01$) nonlinear association with type 2 diabetes in Filipina women, with increased odds of diabetes at both low and high sleep durations independent of age, body mass index (BMI), triglyceride to high-density lipoprotein (HDL) ratio, hypertension, and daytime napping duration. Daytime napping duration was associated with type 2 diabetes only among White women; those napping ≥ 30 min/day had 74% (95% confidence interval (CI) = 10%, 175%) higher odds of diabetes compared to non-nappers independent of covariates including nighttime sleep duration.
Conclusions: Results suggest ethnic-specific associations of nighttime sleep and daytime napping durations with type 2 diabetes.

1. Introduction

The role of sleep duration in healthy aging has received increased attention in recent years, due, in part, to the sharp rise in the prevalence of short sleep duration [1]. Short and long sleep durations are associated with numerous adverse health outcomes, including obesity, hypertension, cardiovascular disease, and all-cause mortality [2–6].

Short and long sleep durations have also been linked to an increased risk of diabetes [7–9]. In a meta-analysis of >100,000 men and women, short (≤5–6 h sleep/night) and long (>8–9 h/night) sleepers had a 28% and 48% increased risk of type 2 diabetes, respectively [10]. However, limited studies have evaluated ethnic variations in the relationship between sleep duration and diabetes [11–13]. Investigating ethnic differences in the sleep–diabetes association is important, given that Blacks have higher rates of short and long sleep compared to Whites, as well as a higher risk of diabetes [1,14]. To our knowledge, no study has included a sample of Filipinos, a group with a disproportionately high diabetes prevalence compared to both Whites and Blacks [15].

Although less studied, daytime napping, which is common among older adults, has also been linked to poor health outcomes including diabetes [16–19]. However, the majority of these studies have been conducted in Chinese populations, and it is currently unknown whether the relationship between daytime napping and diabetes may differ by ethnicity.

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The purpose of this cross-sectional study was to evaluate ethnic differences in the associations of nighttime sleep duration and daytime napping duration with type 2 diabetes in a large sample of older, community-dwelling White, Filipina, and Black postmenopausal women. The prevalence of type 2 diabetes was ascertained by an oral glucose tolerance test, an important consideration in studies of older women, many of whom have isolated post-challenge hyperglycemia that would otherwise be missed [20].

2. Methods

2.1. Participants

Between 1972 and 1974, the Rancho Bernardo Heart and Chronic Disease Study enrolled 6629 community-dwelling residents aged 30–79 years from the southern California community of Rancho Bernardo [21]. Participants were predominantly White, middle class, and relatively healthy. This study uses cross-sectional data from 1082 women aged 30–98 years who attended the 1992–1996 follow-up research clinic visit in which oral glucose tolerance tests, body fat composition, and other measurements (eg, height, weight, and lipids) were obtained.

Two ethnic comparison cohorts of Filipina and Black women were enrolled between 1993 and 1999. An effort was made to recruit Filipina and Black women of similar education and social class to the participants of the Rancho Bernardo cohort. Briefly, community-dwelling Filipina women aged 40–86 years ($n = 453$) were recruited to participate in a cross-sectional study assessing the prevalence of chronic diseases including osteoporosis, type 2 diabetes, and cardiovascular disease [22]. Convenience sampling was employed because Filipinos were not identified separately from Asians in the 1990 census. Most of the Filipina women lived in Mira Mesa, a middle-class community located in North San Diego County with a high proportion of Filipino residents. This population was chosen because it is located 10 miles from our research clinic in Rancho Bernardo, the residence of the White cohort. Black women aged 50–88 years ($n = 443$) were recruited between 1993 and 1997 to participate in the Health Assessment Study of African-American Women (HASAAW), a cross-sectional study on the prevalence of chronic diseases including type 2 diabetes [23]. Black women were chosen to select for white-collar workers to minimize confounding due to social class and access to health care when comparing ethnic differences.

This study was limited to postmenopausal women between 50 and 86 years of age ($n = 1658$) in order to have similar age groups across samples. After excluding women with a missing diabetes diagnosis ($n = 31$), diagnosed with type 1 diabetes ($n = 8$), and missing data on nighttime sleep and/or daytime napping durations ($n = 10$), there remained 908 White, 330 Filipina, and 371 Black postmenopausal women who are the focus of this study. All participants provided written informed consent prior to participation. This study was approved by the Human Research Protections Program of the University of California, San Diego (UCSD) and the Institutional Review Board of San Diego State University.

2.2. Procedures

Clinical evaluations were performed at the UCSD Rancho Bernardo Clinic for White and Filipina women and at the UCSD Clinical Research Center for Black women. The same research protocols and diagnostic laboratories were used for all ethnic cohorts.

A standardized self-administered questionnaire obtained information on nighttime sleep and daytime napping durations using the following two questions: (1) "How many hours do you sleep each night?" and (2) "How many hours do you nap each day?" The questionnaire also obtained information on demographics, medical history, age at last menstrual period, smoking status (never/past/current), alcohol consumption ≥3 drinks/week (yes/no), and exercise ≥3 times/week (yes/no). Occupation was asked as an open-ended question and coded in groups, such that "nurses" were in the same group as teachers and managers (ie, those requiring a bachelor's degree). A trained interviewer obtained information on current use of diabetes, hypertension, and sleep-related medications (eg, sedating antidepressants, antianxiety drugs, and sedative hypnotics). Use of medications in the month before the clinic visit was validated with pills and containers brought to the clinic for that purpose.

In the clinic, height and weight were measured in participants wearing lightweight clothing without shoes. BMI was calculated as weight (kg)/height (m^2). Waist circumference was measured at the natural bending point. Total percentage body fat was measured by dual energy X-ray absorptiometry (DEXA; model QDR-2000; Hologic, Waltham, MA, USA). Systolic and diastolic blood pressures were measured twice in participants after they had been seated quietly for 5 min, using the Hypertension Detection and Follow-Up Program protocol.

Blood samples were collected from participants between 8 and 11 am after an 8-h minimum fast. Participants were administered a 75-g oral glucose tolerance test; blood was collected by venipuncture at 0 and 2 h. Plasma glucose levels were measured by the glucose-oxidase method, and insulin levels by radioimmunoassay (Fineberg Laboratory, Indiana University, Indianapolis, IN, USA). Insulin resistance was estimated with the homeostasis model assessment [24]. Fasting plasma lipids, lipoproteins, and triglycerides were measured with enzymatic techniques (Lipid Research Clinics Program Manual of Laboratory Operations).

2.3. Statistical analysis

Type 2 diabetes was defined by fasting plasma glucose ≥126 mg/dl, 2-h post-challenge glucose ≥200 mg/dl, physician-diagnosed type 2 diabetes, or treatment with an oral hypoglycemic agent or insulin. Hypertension was defined as systolic blood pressure ≥130 mmHg, diastolic blood pressure ≥85 mmHg, or use of antihypertensive medications. Based on the existing literature [4,6,9], nighttime sleep duration was categorized as follows: < 6 h (short), 6–6.9 h, 7–7.9 h (reference), 8–8.9 h, and ≥9 h (long); daytime napping duration was categorized as follows: 0 min (reference), <30 min, and ≥30 min.

Descriptive statistics are presented as percentages or means (standard errors) for categorical and continuous covariates, respectively. For continuous covariates, normality was assessed using frequency distributions, normal probability plots, and measures of skewness and kurtosis. Log-transformed variables are presented as geometric means (95% CI). The mean values of continuous covariates were compared using independent *t*-tests or analysis of variance (ANOVA) in unadjusted comparisons, and general linear models in covariate-adjusted comparisons. Pearson's λ^2 test or Fisher's exact test was used to compare categorical covariates. The Cochran–Armitage test for trend was used to assess dose–response associations.

Univariate associations of duration of nighttime sleep and daytime napping and other variables with diabetes were assessed using logistic regression. The possibility of a U-shaped association of nighttime sleep duration with diabetes was tested using a quadratic term centered on the mean value to avoid multicollinearity. In multivariable logistic regression analysis, separate models were fit for White, Filipina, and Black women. The full multivariable models included nighttime sleep and daytime napping durations, as well as variables marginally associated ($0.05 \le p < 0.10$) with nighttime sleep duration, daytime napping duration, and/or diabetes in the univariate analyses (ie, age, BMI, triglyceride to HDL ratio, hypertension, exercise, alcohol, and medication use for depression, anxiety, or insomnia medications). The final models were derived using stepwise backward elimination with assessment for confounding; if the

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removal of a variable changed the strength of the association between the exposure of interest (eg, nighttime sleep duration) and diabetes by at least 10%, then it was defined as a confounder and kept in the final model. Multicollinearity between independent variables was assessed using tolerance values. Odds ratios (OR), 95% CI, and *p*-values are reported. All *p*-values (with the exception of test for trend) were two-sided with $p < 0.05$ considered statistically significant. Statistical analyses were performed using SAS Version 9.3 (SAS Institute, Cary, NC, USA).

3. Results

Table 1 shows age-adjusted characteristics of study participants by ethnicity. White women were significantly older than Filipina and Black women (mean age = 71.1, 62.4, and 62.3 years, respectively), and White and Filipina women had a significantly lower BMI and waist girth compared to Black women. Filipina women were less likely to ever smoke, drink alcohol, or use anxiety medications, and they had the highest diabetes prevalence, triglyceride to HDL ratio, fasting plasma glucose, and 2-h glucose levels compared to the other ethnic groups. There were significant ethnic differences in nighttime sleep duration, with White women having the highest duration, and Filipina and Black women having similar lower durations. White women had significantly shorter daytime napping duration compared to both Filipina and Black women.

Age- and ethnicity-adjusted comparisons of clinical, behavioral, and lifestyle characteristics according to nighttime sleep and daytime napping durations are presented in Table 2. Compared to women sleeping 7–7.9 h/night, women with the longest sleep duration were older, more likely to drink alcohol and use anxiety or depression medications, and had the highest 2-h glucose levels. Short (<6 h) and long (≥9 h) sleepers had the highest average daytime napping duration. There were no significant differences in diabetes prevalence, fasting plasma glucose, BMI, waist girth, triglyceride to HDL ratio, hypertension, or smoking by nighttime sleep duration. In ethnic-specific analyses, diabetes prevalence varied by sleep duration in Filipina women ($p = 0.07$), with the highest prevalence at ≥9 h ($n = 10$; 80.0%) followed by <6 h ($n = 87$; 40.2%) of sleep, and lowest at 6–6.9 h ($n = 111$; 33.3%).

Compared to non-nappers or those napping <30 min, those napping ≥30 min were older, and had the highest BMI, waist girth, triglyceride to HDL ratio, and 2-h glucose levels (Table 2). A dose–response association of daytime napping duration on diabetes prevalence was observed ($p < 0.01$), with the highest prevalence among women napping ≥30 min/day (22.3%) and lowest among those who did not nap (15.7%). There were no significant differences in nighttime sleep duration, hypertension, fasting plasma glucose, alcohol, smoking, or medication use by daytime napping duration. In ethnic-specific analyses, there was a significant ($p < 0.01$) dose–response association of napping with diabetes in White women only, with the highest prevalence in women napping ≥30 min/day ($n = 287$; 17.3%) followed by <30 min/day ($n = 92$; 11.4%) and 0 min/day ($n = 529$; 8.5%).

Table 3 shows the results of separate multivariable models examining the associations of nighttime sleep and daytime napping durations with diabetes by ethnicity. In multivariable models, categorical sleep duration was not significantly associated with diabetes in White or Black women (Fig. 1). However, among Filipina women, long sleep duration was associated with increased odds of diabetes (OR = 5.96; 95% CI = 1.07, 33.10).

Among Filipina women, a quadratic term for sleep duration was significantly associated ($p < 0.01$) with diabetes before and after adjustment for confounders. Fig. 2 shows the adjusted odds of diabetes by nighttime sleep duration for the model with a quadratic term, after excluding outliers including sleep durations of <3 h ($n = 2$) and >10 h ($n = 1$). The odds of diabetes were lowest at approximately 6 h of sleep duration and increased in a nonlinear manner, with the greatest likelihood of diabetes at both low and high sleep durations. We also found that among Filipina women, a quadratic term for sleep duration was significantly associated with impaired glucose tolerance (2-h post-challenge glucose 140–199 mg/dL; data not shown).

Table 1
Age and age-adjusted comparisons of covariates by ethnicity ($n = 1609$).

	White ($n = 908$) Mean (SE)	Filipina ($n = 330$) Mean (SE)	Black ($n = 371$) Mean (SE)
Age (years)	71.1 (9.5)[b,c]	62.4 (6.9)	62.3 (8.3)
BMI (kg/m^2)	25.2 (0.16)[c]	24.9 (0.26)[d]	29.6 (0.25)
Waist girth (cm)	80.3 (0.40)[c]	81.0 (0.65)[d]	88.5 (0.61)
Total body fat (%)	34.4 (0.27)[b,c]	33.2 (0.43)[d]	36.3 (0.41)
HDL cholesterol (mg/dL)	64.7 (0.56)[b]	54.3 (0.91)[d]	63.1 (0.87)
Triglycerides[a] (mg/dL)	107.3 (103.6–111.1)[b,c]	134.3 (126.9–142.2)[d]	82.4 (78.1–87.0)
Triglyceride to HDL ratio[a]	1.7 (1.6–1.8)[b,c]	2.6 (2.4–2.7)[d]	1.4 (1.3–1.5)
Fasting plasma glucose[a] (mg/dL)	93.5 (92.3–94.8)[b,c]	106.4 (104.1–108.8)[d]	96.7 (94.6–98.7)
2-h glucose[a] (mg/dL)	128.4 (125.2–131.6)[b]	181.5 (174.6–188.7)[d]	133.5 (128.7–138.5)
HOMA-IR[a]	2.1 (2.0–2.1)[b,c]	2.6 (2.5–2.8)	2.6 (2.5–2.8)
Nighttime sleep duration (h)	7.3 (0.04)[b,c]	6.3 (0.07)[d]	6.6 (0.07)
Daytime napping duration (min)	16.8 (1.3)[b,c]	31.7 (2.1)	25.9 (2.1)
Total sleep + nap duration (h)	7.6 (0.05)[b,c]	6.8 (0.08)	7.0 (0.08)
	%	%	%
Hypertension	60.2[c]	76.2	83.2
Smoker (ever)	52.5[b,c]	14.7[d]	49.3
Alcohol (≥3 drinks/week)	40.6[b,c]	0.63[d]	10.8
Exercise (≥3 times/week)	68.3[c]	70.3[d]	57.7
College graduate	28.9[b,c]	43.6	37.5
Current anxiety medication	2.7[b,c]	0.8[d]	6.6
Current depression medication	3.2	1.8[d]	5.6
Current insomnia medication	6.7	8.0	5.3
Type 2 diabetes	10.9[b]	37.8[d]	17.8

HOMA-IR, homeostasis model assessment of insulin resistance.
[a] Log-transformed variables presented as geometric mean (95% CI).
[b] $p < 0.05$, White versus Filipina; [c] $p < 0.05$, White versus Black; [d] $p < 0.05$, Filipina versus Black.

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Table 2
Age- and ethnicity-adjusted comparisons of covariates by reported nighttime sleep duration and daytime napping duration ($n = 1609$).

	Sleep Duration						Napping Duration		
	<6 h ($n = 215$)	6–6.9 h ($n = 398$)	7–7.9 h ($n = 434$)	8–8.9 h ($n = 460$)	≥9 h ($n = 102$)	*p*-value	0 min ($n = 913$)	<30 min ($n = 162$)	≥30 min ($n = 534$)	*p*-value
Age (years)	65.8 (0.60)	65.6 (0.44)	64.3 (0.44)	65.1 (0.45)	68.1 (0.89)	<0.01	63.5 (0.31)	66.5 (0.68)	67.8 (0.38)	<0.001
BMI (kg/m^2)	27.3 (0.32)	26.7 (0.24)	26.3 (0.24)	26.2 (0.24)	26.5 (0.47)	0.06	26.3 (0.17)	26.3 (0.37)	27.0 (0.21)	0.01
Waist girth (cm)	84.7 (0.78)	83.3 (0.58)	82.9 (0.58)	82.4 (0.59)	84.1 (1.2)	0.16	82.5 (0.43)	82.8 (0.91)	84.6 (0.51)	<0.01
Total body fat (%)	34.4 (0.53)	34.5 (0.39)	34.2 (0.40)	35.1 (0.40)	35.5 (0.79)	0.38	34.4 (0.29)	34.4 (0.61)	35.0 (0.35)	0.36
Triglyceride to HDL ratio[a]	1.9 (1.8–2.1)	1.7 (1.6–1.9)	1.8 (1.7–2.0)	1.7 (1.6–1.9)	2.0 (1.7–2.3)	0.13	1.7 (1.6–1.8)	1.7 (1.6–1.9)	2.0 (1.8–2.1)	<0.01
FPG[a] (mg/dL)	101.5 (97.0–102.4)	98.0 (96.1–100.0)	98.3 (96.4–100.3)	98.6 (96.6–100.7)	101.5 (97.5–105.6)	0.56	98.1 (96.6–99.5)	97.2 (94.2–100.3)	100.1 (98.3–101.9)	0.12
2-h glucose[a] (mg/dL)	147.8 (140.9–155.1)	143.0 (138.0–148.1)	143.7 (138.7–148.9)	148.2 (143.0–153.7)	159.2 (147.8–171.5)	0.08	143.1 (139.5–146.9)	142.7 (135.1–150.8)	151.6 (146.9–156.5)	0.01
HOMA-IR[a]	2.5 (2.3–2.7)	2.4 (2.2–2.5)	2.4 (2.3–2.5)	2.4 (2.3–2.6)	2.7 (2.4–3.0)	0.39	2.4 (2.3–2.5)	2.3 (2.1–2.5)	2.5 (2.4–2.7)	0.10
Napping or sleep duration	30.0 (2.6)	24.9 (1.9)	19.6 (1.9)	24.5 (2.0)	33.9 (3.9)	<0.01	6.7 (0.05)	6.7 (0.10)	6.7 (0.06)	0.87
Hypertension	72.0%	74.6%	67.9%	69.5%	73.3%	0.11	69.7%	69.2%	72.3%	0.35
Alcohol (≥3 drinks/week)	20.9%	21.1%	27.2%	27.8%	32.5%	0.04	27.0%	30.0%	24.0%	0.18
Exercise (≥3 times/week)	51.5%	65.1%	68.6%	71.6%	67.9%	<0.001	64.3%	73.4%	65.2%	0.03
Smoker (ever)	51.8%	45.1%	45.0%	42.7%	38.1%	0.18	47.3%	41.4%	43.2%	0.17
Current anxiety medication	4.1%	1.8%	3.1%	2.1%	5.2%	0.04	3.2%	2.0%	2.7%	0.47
Current depression medication	4.1%	2.6%	1.8%	3.4%	7.9%	<0.01	2.4%	4.1%	4.0%	0.07
Current insomnia medication	15.8%	9.1%	5.6%	4.5%	3.2%	<0.001	6.3%	7.0%	8.8%	0.16
Type 2 diabetes	18.8%	15.8%	18.5%	18.7%	29.5%	0.19	15.7%	18.7%	22.3%	<0.01

[a] Log-transformed.
Data are means (SE) for continuous variables and geometric means (95% CI) for log-transformed variables.
FPG, fasting plasma glucose; HOMA-IR, homeostasis model assessment of insulin resistance.

Daytime napping duration was not significantly associated with diabetes in Filipina or Black women in multivariable models (Table 3; Fig. 3). By contrast, among White women, the odds of diabetes were significantly higher among women napping ≥30 min/day (OR = 1.74; 95% CI = 1.10, 2.75) compared to women not napping. With daytime napping duration modeled as a continuous log-transformed variable, the odds of diabetes were significantly elevated among White women (OR = 1.15; 95% CI = 1.03, 1.29).

4. Discussion

In this sample of older, community-dwelling postmenopausal women, there were ethnic differences in the associations of self-reported nighttime sleep and daytime napping durations with diabetes. In Filipina women, sleep duration was significantly associated with diabetes in a nonlinear manner, with increased odds of diabetes at both low and high sleep durations independent of age, BMI, triglyceride to HDL ratio, hypertension, and daytime napping duration. Daytime napping duration was associated with diabetes only among White women, with those napping ≥ 30 min/day having increased odds of diabetes after adjusting for covariates including nighttime sleep duration.

Results of the present study are in accord with other studies of White women that also reported a lack of association of sleep duration with diabetes [25]. Additionally, a prospective study of 2663 Swedish men and women reported that difficulties maintaining sleep and sleeping ≤5 h/night were associated with diabetes risk in men, but not women [26]. In the present study, the associations of short and long sleep durations with diabetes were also nonsignificant in Black women despite their higher prevalence of disease. Similarly, a recent study evaluating data from the National Health and Nutrition Examination Survey (NHANES) reported that very short (<5 h) or long (≥9 h) sleep were not significantly associated with objectively measured diabetes in Black or White participants [4]. However, analysis of the 2005 National Health Interview Survey (NHIS) showed that, among both Blacks and Whites, long sleep duration was associated with self-reported diabetes independent of sociodemographic characteristics (eg, age, sex, and income) and comorbid medical conditions [12]. Finally, a recent study found that suboptimal sleep duration had stronger associations with diabetes in Whites compared to Blacks in both short and long sleepers [13]. These divergent findings may be attributed to differences in age, sample size, culture, and diabetes definition. For example, some studies used self-reported diabetes [13,26]; others used fasting glucose but did not include an oral glucose tolerance test as part of the diabetes definition [25]. Additionally, previous studies did not examine the sleep–diabetes relation by sex and used samples that were comparatively younger than the older, postmenopausal women in our study [4,12,13]. Finally, the lack of an association of sleep duration with diabetes in White women in our study may be due to insufficient power caused by low diabetes prevalence in this group.

Blacks have previously been found to have a higher risk for diabetes compared to Whites [14], in addition to a higher prevalence of extreme sleep durations [1]. Socioeconomic status (SES) has been identified as a contributing factor to these observed differences [27]. Concordant with these observations, we found a shorter average sleep duration and higher diabetes prevalence in Black compared to White women. However, SES is not a likely explanation of our findings, as participants were selected so as to have similar SES, reducing the potential confounding effect of this variable.

To our knowledge, this is the first study to evaluate the association between sleep duration and diabetes among Filipinos. Few studies have evaluated the sleep–diabetes relation in Asians, and Asian Americans have been shown to report a high level of sleep complaints [28]. Although a recent cross-sectional study based on NHANES data reported that short or long sleep were not

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Table 3
Adjusted odds of type 2 diabetes by nighttime sleep duration and daytime napping duration within each ethnic group.

	White ($n = 901$)	p-value	Filipina ($n = 330$)	p-value	Black ($n = 370$)	p-value
Nighttime sleep duration[a]						
<6 h	0.83 (0.35,1.99)	0.68	0.92 (0.47,1.81)	0.81	0.66 (0.26,1.72)	0.40
6–6.9 h	0.61 (0.33,1.16)	0.13	0.75 (0.39,1.43)	0.38	0.95 (0.42,2.13)	0.89
7–7.9 h	1.00		1.00		1.00	
8–8.9 h	0.76 (0.45,1.28)	0.30	0.95 (0.41,2.19)	0.90	1.55 (0.69,3.45)	0.29
≥9 h	0.77 (0.36,1.67)	0.51	5.96 (1.07,33.10)	0.04	2.13 (0.52,8.80)	0.29
Daytime napping duration[b]						
0 min	1.00		1.00		1.00	
<30 min	1.42 (0.70,2.88)	0.33	0.86 (0.41,1.83)	0.70	1.32 (0.40,4.37)	0.65
≥30 min	1.74 (1.10, 2.75)	0.02	1.27 (0.75, 2.15)	0.38	1.18 (0.59, 2.35)	0.65
Napping duration, continuous[c]	1.16 (0.99, 1.37)	0.06	1.06 (0.93, 1.21)	0.14	1.03 (0.86, 1.23)	0.77
Napping duration, log-transformed	1.15 (1.03, 1.29)	0.01	1.14 (0.96, 1.35)	0.36	1.05 (0.90, 1.23)	0.53

[a] Models adjusted for age, BMI, triglyceride to HDL ratio, hypertension, and daytime napping duration in Whites and Filipinas, and all of these factors except hypertension in Blacks.
[b] Models adjusted for age, BMI, triglyceride to HDL ratio, hypertension, and nighttime sleep duration in Whites and Filipinas, and all of these factors except hypertension in Blacks.
[c] Per 30-min increase.

significantly associated with diabetes in an Asian/other group [4], Asian subgroups were not examined separately. Given the substantial heterogeneity in diabetes risk across the Asian population [15], risk factors for diabetes may also vary across Asian subgroups. Higher rates of diabetes have been observed in Filipinos compared to non-Hispanic Whites and other ethnic minorities including African Americans and Latinos [15], with one study noting an approximate fourfold increased odds of diabetes in Filipina compared to non-Hispanic White women [29]. However, mechanisms explaining these ethnic differences in diabetes risk are poorly understood. Two prior studies using this study's Filipina cohort showed that the higher prevalence of diabetes among Filipina compared to White women was not explained by differences in education, smoking, parity, body size, fat distribution, percentage of body fat, or visceral adipose tissue [22,30]. Whether sleep duration partially accounts for these ethnic differences in diabetes risk has not been yet explored and requires further study.

Ethnic differences in sleep duration and daytime napping duration were observed in our study. Average sleep duration was highest in White women and lower in Filipina and Black women, consistent with previous findings [13]. The highest average daytime napping duration was observed among Filipina women, and the lowest among White women. In the overall sample, short and long sleepers had the highest average daytime napping duration. In contrast, the 2003 Sleep in America Study showed that sleeping ≥9 h/night was not associated with increased napping [16]. Daytime naps may be taken by individuals with sleep deprivation due to work shifts or among those with excessive daytime sleepiness caused by an underlying sleep disorder preventing quality sleep at night [31]. On the other hand, habitual naps are common among older adults, and a survey conducted by the National Sleep Foundation in 2005 reported that 55% of adults take ≥1 nap during the week [27]. Similarly,

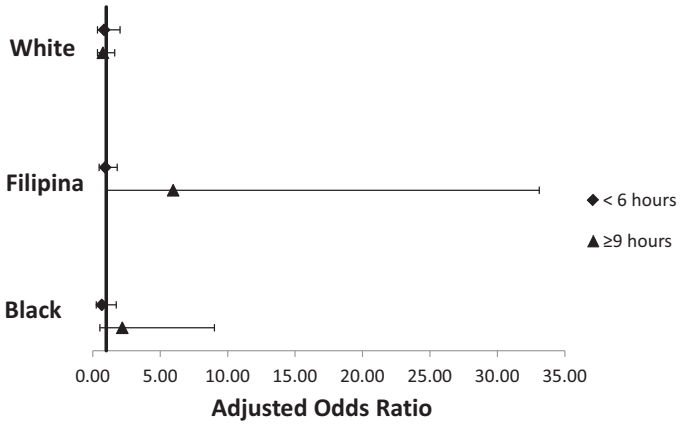

Fig. 1. Adjusted odds of type 2 diabetes by sleep duration and ethnicity (reference category: 7–7.9 h sleep duration).

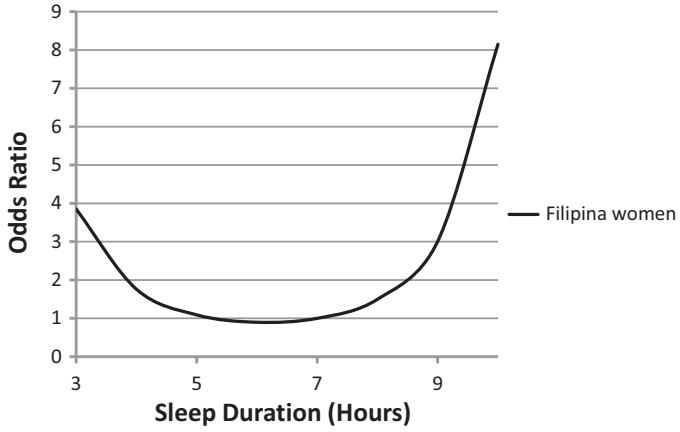

Fig. 2. Adjusted odds of type 2 diabetes by sleep duration in Filipina women. The adjusted odds are based on a logistic regression model adjusted for age, BMI, triglyceride to HDL ratio, hypertension, and daytime napping duration with sleep duration modeled as a quadratic term ($p < 0.01$ for sleep duration).

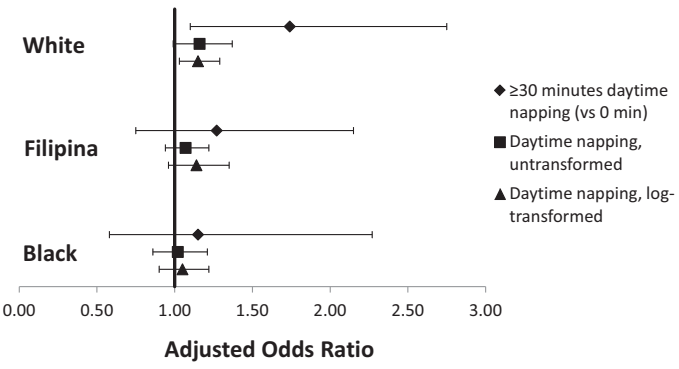

Fig. 3. Adjusted odds of type 2 diabetes by daytime napping duration and ethnicity.

in our study, a longer nap duration was more common in older women. Napping is also a cultural phenomenon and practiced with varying frequencies in different populations [27]. We found that napping was less common in Whites, consistent with a previous finding [19].

In our study, the association between daytime napping and diabetes was significant among White women napping ≥30 min/day, but this association was not present in Black or Filipina women. There is limited literature on the association of daytime napping with diabetes. Most studies of napping in relation to diabetes have been conducted in China [17,18], where daily napping is common practice. In one study conducted in older White women, napping <1 h and ≥1 h/day compared to not napping increased the risk for diabetes independent of physical activity and BMI [19].

Napping may have several benefits for older adults, including reduced daytime sleepiness and improvements in sleep quality and cognitive functioning (eg, alertness, concentration) [32]. Napping has also been associated with adverse health outcomes in older adults, including an increased risk of mortality [33,34]. Regarding the length of nap duration, 10–20 min of napping may improve cognitive performance and alertness, whereas naps of ≥30 min may lead to sleep inertia and negatively affect cognitive functioning [32]. Our results suggest that naps of ≥30 min may also be associated with diabetes, consistent with previous studies [17,18].

Short sleep may increase the risk for the development of diabetes via varying mechanisms involving changes in glucose metabolism and hormones. Sleep loss can result in decreased glucose tolerance and insulin response, leading to insulin resistance over time [35]. Leptin, an adipocyte-derived hormone that suppresses appetite, is reduced due to sleep loss, whereas ghrelin, a stomach-derived peptide that stimulates appetite, is enhanced as a result of sleep loss; the subsequent rise in caloric intake and increase in body weight is a risk factor for the development of diabetes [35,36]. Sleep loss can also lead to elevated cortisol concentrations with consequent reductions in insulin sensitivity [35], and a recent study suggested that the relation between sleep loss and diabetes is mediated by reduced melatonin secretion causing insulin resistance [37].

The physiologic pathways explaining the association between long sleep duration and diabetes are currently unclear. One possible explanation is that the long sleep–diabetes relation is due to residual confounding by factors such as depression, which is associated with diabetes and can adversely affect sleep quality [38,39]. However, given the low prevalence of antidepressant use among Filipina women in our study, this explanation is unlikely. It has also been postulated that long sleep duration is a consequence of diabetes (ie, reverse causation) [9].

The precise mechanisms linking daytime napping to an increased risk for diabetes have not been studied. One possible explanation is that daytime napping is a consequence of diabetes or other underlying comorbidities [40]. Napping due to excessive daytime sleepiness may also be a marker of poor sleep quality (eg, short sleep duration and difficulty falling and maintaining sleep) or obstructive sleep apnea, which have been previously associated with diabetes [16,26,41,42]. However, in our study sleep duration did not vary according to length of nap duration, and napping ≥30 min was associated with diabetes independent of BMI (a predictor of sleep apnea) [38], making this an unlikely explanation of our findings.

Our study has several limitations. Its cross-sectional nature precludes the ability to examine a causal association between sleep duration, daytime napping, and diabetes. Furthermore, sleep duration and daytime napping were self-reported and not objectively measured. Therefore, distinctions could not be made between time awake in bed and physiologic sleep as measured by actigraphy. We also did not measure other characteristics indicative of poor sleep quality, including trouble falling asleep, sleep maintenance difficulties, daytime sleepiness, and sleep apnea, which may affect diabetes and could have confounded our findings; however, we controlled for daytime napping in our sleep duration models and vice versa. We also did not determine the frequency of or reason for napping. One-third of the Filipina women were working as nurses, and thus residual confounding due to working in shifts is possible. Finally, participants in our study were mostly middle class, limiting generalizability of our findings; however, this mitigates confounding due to SES.

This study also has a number of strengths including a large multiethnic sample of White, Black, and Filipina women allowing stratified analyses. Additionally, our sample consisted only of postmenopausal women, reducing the confounding effect of menopausal symptoms such as night sweats and hot flashes, which may affect sleep quality and quantity; previous studies evaluating older women often fail to control for these factors. Information on a large number of covariates was collected, including metabolic characteristics, lifestyle habits, and validated medication use. Finally, diabetes was assessed objectively using both fasting plasma glucose and an oral glucose tolerance test, an important consideration in studies of older women, many of whom have isolated post-challenge hyperglycemia [20].

In conclusion, ethnic differences in the relation between sleep duration, napping duration, and diabetes were observed in our study, with Filipina women having a significant quadratic association of sleep duration with diabetes and White women napping ≥30 min/day having an approximate twofold increased odds of diabetes. Future prospective studies are warranted to determine if sleep and napping durations may represent important, previously unrecognized risk factors for diabetes according to the ethnic group.

Conflict of interest

The ICMJE Uniform Disclosure Form for Potential Conflicts of Interest associated with this article can be viewed by clicking on the following link: http://dx.doi.org/10.1016/j.sleep.2014.11.010.

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